1. Next generation science policy and Grand Challenges*

Stefan Kuhlmann and Arie Rip

A NEXT GENERATION OF SCIENCE AND SCIENCE POLICY

The idea of a 'next generation', here of science policy, is rhetorically powerful. On the one hand, it invites the reader to consider what is changing, and diagnose what these changes are about. On the other hand, it also conveys a sense of inevitability of the changes. An example from the 1990s and early 2000s of a perceived generational shift in science policy is the analysis, by Michael Gibbons et al. (1994), of a new mode of knowledge production, which they call 'Mode 2' and which is the successor to 'Mode 1': the numbering creates rhetorical force in the same way the label 'next generation' does.[1] At its height as a science policy fashion it was a triumphant narrative (Rip 2014): Mode 2 is upon us, inevitably, and you had better not resist, or you will be left behind. Such a triumphant narrative can certainly raise attention and a sense of urgency.

By using the notion of 'next generation' in the title of this chapter, we run the risk of appearing to accept the above-mentioned connotations. But we play it safe because we do not have a strong overall diagnosis that we want to spread: in the next section we will discuss ongoing changes, but as a patchwork. Also, we do not have a strong message about how to do better: in the third section we identify the interest in challenge-oriented science policy, and then discuss the challenge of actually addressing it. In the last section we will sketch emerging modes of governance that have the potential to cope with the 'challenge of addressing Grand Challenges'. Thus, our discussion of Grand Challenges is more like a prospective case-study of science policy rather than a push for doing more about Grand Challenges – although we would not be against that.

There are other examples of diagnosing important changes in science and drawing out implications for science policy. An early case from the late 1950s and early 1960s is the idea of 'Big Science' as the next phase (or generation) after the age of 'Little Science' – compare with the title of a book by Derek de Solla Price, *Little Science, Big Science* (1963). A more recent example, from the late 1980s, is the diagnosis of John Ziman and others, of a 'Steady State

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Science' being upon us. It was a very British concern at the time, but part of larger diagnosis.[2] Since then we have seen the emergence of the 'Triple Helix' diagnosis (Etzkowitz and Leydesdorff 2000), which has become an intellectual community of academics as well as science policy practitioners (see Chapter 18 by Etzkowitz and Zhou, this volume), with its own meetings and newsletter, but also a widely used catch word. In addition, there is the diagnosis of Jerry Ravetz of 'post-normal science' (Funtowicz and Ravetz 1993), the identification, by Arie Rip, of 'Strategic Science' as the new regime (Rip 2000; 2002; Irvine and Martin 1984), and the call, by Michel Callon and collaborators, for what they see as 'Technical Democracy' (Callon et al. 2001).

The empirical support for the various diagnoses is suggestive rather than conclusive. What appears to be clear, however, is that there is an opening up of an earlier, stabilised and often inward-looking regime of knowledge production (Markus et al. 2009).

For our topic, changes in science policy, two recent considerations are particularly important. First, the idea of successive 'framings' of science policy, from the post-world war 'Endless Frontier' (Bush 1945) with its linear-sequential view of scientific knowledge creation and welfare generation, as a first frame, and the more connectionist view of integrated national systems of research and innovation, as a second frame, to a recent, and still programmatic, third framing of science and innovation policy for transformative change (Schot and Steinmueller 2018). The third framing combines analysis, diagnosis and the need to spread a normative message: the global inequality and the Sustainable Development Goals are calling for transformative change of socio-economic systems, including science and innovation policy.

The second consideration refers to the emergence of a so-called challenge orientation as a key element in present-day science policy (see Lund Declaration 2009; European Commission's Framework Programme for Research and Innovation Horizon 2020). It has the trappings of a fashion, because the notion of 'Grand Societal Challenges' is easy to refer to, and has now developed a life of its own. But it also indicates an attempt to capture and name changing practices and contexts, and to come to terms with them. That is a good reason to look more closely at the fashion, and consider it as an important part of a next generation of science policy.

ONGOING CHANGES IN SCIENCE POLICY: A PATCHWORK

In addition to the changes in the way science is being practised, at the level of knowledge production and at the level of institutions, such as

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the move from Mode 1 to Mode 2, there are two concurrent clusters of changes which may well reinforce each other: first, the opening up of existing actor constellations and the entrance of new actors; and second, the ongoing move away from prescriptive modes of governance towards 'concertation' rather than coordination. In addition, a growing number of science policy actors have become interested in the directionality of science policy, as with Grand Challenges. In view of ongoing and required system transformation efforts and with the entrance of new actors, both in knowledge production and science policy, incumbent modes of public governance of science (canonising knowledge; purposive public agency) can fall short. Openings in actor constellations may become possible and required. Next to incumbent science organisations, governmental organisations and funding councils, also civil society organisations (CSOs), transnational knowledge platforms like the Intergovernmental Panel on Climate Change (IPCC), philanthropic organisations, new international university research ventures (Youtie et al. 2017), and knowledge-based private corporations (such as Google) are entering the arena. New types and mixtures of interventions in knowledge production are emerging; even large-scale experimentation to address ill-defined Grand Challenges could be facilitated. At the same time, aims and expectations of old and new actors can be contentious and may provoke power struggles.

One striking phenomenon is how new actors are joining policy arenas and public debates, and entering newly emerging spaces (Rip and Joly 2012) more generally, transcending the scope and involvement of 'classical' policy 'stakeholders' (Kuhlmann 2001). Examples of such new actors in thematic domains like sustainable energy production and consumption include, for instance, not only 'classical' environmentalist groups but also local energy initiatives (Arentsen and Bellekom 2014); in health-related domains we find patient organisations, often in collaboration with philanthropic organisations, pro-actively shaping debates and agendas (Boon et al. 2011). One could characterise what is happening as that agency appears no longer as mainly centralised (e.g. by national government) but as distributed, and driven by institutional entrepreneurs (Battilana et al. 2009), including CSOs.

We note that the issue of distributed agency is actually more complex, because central government has always included elements of delegation. Territorial, of course, but also sectoral, as in neo-corporatism (Schmitter 1985). Corporatism may be different in the form of participation compared with present opening-up, but not different in principle. The efforts to institutionalise 'Constructive Technology Assessment' exercises, for example, can imply a bypassing of central decision making and the

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creation of new forms of neo-corporatism, possibly more reflexive than traditional neo-corporatism (Fisher and Rip 2013).

New actors, as well as incumbent actors in changing contexts, such as firms involved in disruptive innovation, require financial resources and media attention, and they seek to gain legitimation, including a 'social licence to operate'. Introducing explicit directionality, such as the ambition to address Grand Societal Challenges, can work as a resource and help to establish legitimacy. One could interpret this process with the help of the Advocacy Coalition Framework (Sabatier and Jenkins-Smith 1993), yet directionality claims 'towards transformation' exceed the classical setting of government and stakeholder actors and agenda-setting routines.

A related key phenomenon is 'concertation', a form of coordination by mutually taking actions of others into account and pro-actively adjusting, thus creating the basis for concerted action. This horizontal coordination can be contrasted with vertical coordination, that is, 'orchestration' by a central actor. Of course, this is not a complete dichotomy. There will be attempts at orchestration by different actors, with various success. Concertation in practice will look like a patchwork. So our understanding of concerted action differs from the older neo-corporatist understanding of welfare state governance, in particular in Germany in the 1960s and 1970s (e.g. Lehmbruch 2003), not at least in labour policies (e.g. Hudson 1980; Compston 2003). Rather, concertation in science and innovation policy can be considered as a governance mode of 'broader, more diverse "varieties of cooperation"' in advanced capitalist economies (Ornston and Schulze-Cleven 2015, 575).

An example of new spaces for concertation are the European Technology Platforms, some of them leading on to Joint Technology Initiatives. They were set up from 2004 onwards, building on existing networks and initiatives and stimulating new ones. Strategy documents would be created identifying challenges, coordination would occur, and – hopefully – action taken. The themes often show a technology supply orientation, but there are references to broader issues like sustainability (Fresco et al. 2015). More recently the European Commission has introduced a 'mission-orientation' with explicit modes of selection of missions, of engaging citizens and of embedment of missions in the landscape of EU policies and instruments (European Commission 2018; Mazzucato 2016). When writing this chapter it was still too early for an assessment of the effectiveness of such efforts.

A recent example is the creation of a 'Transformative Innovation Policy Consortium (TIPC)', initiated by the Science Policy Research Unit (SPRU) at the University of Sussex, a collaboration platform of SPRU with organisations such as Colciencias, the Government of

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Colombia's Department of Science, Technology and Innovation; the National Research Foundation in South Africa; and the Research Council of Norway. The Consortium aims 'to examine and expand on current innovation frames and approaches to assist in solving urgent social and economic issues of our time'. The platform also seeks to engage in policy design and experimentation, training and skill formation. 'The project involves building new platforms for a mutual learning process between the Global North and South and between research and policy.'[3]

Such moves are part of evolving de facto governance arrangements (Rip 2010). Directionality can turn into strategies, but these are patterns (de facto) rather than intentional strategies (Mintzberg and Waters 1985). Institutional entrepreneurs (governmental, industrial and societal) can modulate de facto governance and nudge publics, media and politics into desired directions.

SCIENCE POLICY ADDRESSING 'GRAND SOCIETAL CHALLENGES', A GOVERNANCE CHALLENGE

Grand (Societal) Challenges as for example addressed by the Lund Declaration (2009), including global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security, or as the Sustainable Development Goals,[4] including areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, are considered to require transformation across societies and economies globally, including the institutions, practices and policies for science and innovation.

We understand this move towards a challenge orientation as a key driver on the way to a next generation of science policy, both as a description of what is happening and as a diagnosis of what is desirable. As noted above, such a dual mode of thinking and analysis is integral to the notion of a 'next generation': something that happens, as well as something that carries a promise for the future. One can then enquire into the options and limitations of governance to realise the promise.

This is important because the governance challenge of addressing Grand Challenges is all too often flattened by reverting to traditional science, technology and innovation policy approaches. The challenge of addressing Grand Challenges is much broader than a next stage in mission orientation and priority setting. This point has been made before (Foray et al. 2012; JIIP 2012), but it needs more attention. Grand Challenges can be considered as being transformative in the sense that they are part of overall societal development rather than just arguments for setting priorities in

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current research and innovation systems (in policies, in practices). Grand Challenges create occasions (and incentives) for new constellations of science and innovation actors to emerge and become active. Public–private partnerships in science and innovation policy, when transformative, are an earlier example of such dynamics.

As a consequence, addressing Grand Challenges is a challenge in its own right, for policy as well as for science, technology and innovation actors. It requires the willingness to explore varieties of extant and new approaches. A next generation of science policies will engage 'science' in the transformation of larger socio-economic systems. The concertation of diverse incumbent and new actors in governments, private businesses and societal organisations will be an important characteristic of this next generation.

If Grand Challenges were just seen as priorities for knowledge and innovation stimulation, and treated that way, say, through dedicated public funding (e.g. OECD 2016), one would miss out on the actual challenges. Given their complex characteristics, and due to the fact that different actors have different views and interpretations of Grand Challenges, they should be seen as open-ended missions, and missions concerning the socio-economic system as a whole, often inducing or requiring system transformation (Kuhlmann and Rip 2018; Schot and Steinmueller 2018; Giuliani 2018). Thus, Grand Challenges are ambitious, but not in the way the Manhattan Project (to develop an atom bomb) and the Apollo Program (to put a man on the moon) had been. There, the challenge was technical as well as organisational, and whether the goals were achieved or not was unambiguous (cf. also Foray et al. 2012). Grand Challenges, though, pertain to heterogeneous elements and forces, which have to be mobilised, guided and integrated, and include social innovation. Many different actors need to be involved, and the perspectives on what is the problem and what constitutes its resolution differ across various societal groups. Also, we see both 'drivers of novelty and innovation as well as processes of capture and co-optation . . . involved' (Kallerud et al. 2013, 4). Hence, Grand Challenges policies have to cope with contestation, non-linearity and bifurcations in developments. This is not a message of despair, but it does imply that our present understandings, instruments and practices of science and innovation policy are not sufficient to address Grand Challenges.

Another relevant driver closely related to the perception of Grand Challenges is the ongoing, diffuse societal agenda-building occurring all the time, for example when actors (companies, also various government agencies) start referring to 'green energy', to create symbolic resources (legitimacy), but then become imprisoned by their own tactics: they have to provide evidence of relevant action so as not to lose legitimacy.

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Eventually, 'green energy' becomes a forceful repertoire, part of the culture of our late-modern societies (Schot et al. 1997).

The nature and constellation of actors involved in science and other policy initiatives addressing Grand Challenges will differ depending on how the 'nature' of a Grand Challenge is perceived and constructed. The nature of a challenge is not a stable fact; it will depend on actor perspectives, interests and power and on available and changing knowledge, scientific and otherwise. Hence, the nature of a Grand Challenge will often be contested and has to be negotiated. As a consequence, over time the perception of the nature of a challenge will evolve and relevant policy approaches will change. Like in the climate change debate, one can distinguish mitigation from adaptation approaches: one could try to mitigate or change the drivers or causes of the changes that constitute the challenge, or seek to adapt to their effects (perhaps because the causes appear to be difficult or impossible to change). For the challenge of the ageing society, mitigation may not be in order, but for drinking water supply one would like to work towards mitigation rather than just adaptation.

In all cases, there are good reasons to include a larger variety of actors and consider new roles for traditional actors. A more inclusive, sociotechnical system-oriented approach can be achieved in several complementary ways. First, key actors should be involved, which implies that actor consortia should be public–private. Also, charitable foundations should play a key role, because they are free to move, and tend to go for public interest goals. Second, in addition to economic aspects, social aspects and changes are a key part of addressing Grand Challenges. Hence, social innovation and related scientific research will have to be considered, including ongoing debates on modes and directions of social innovation (van der Have and Rubalcaba 2016). Third, intermediary organisations and spaces for interactions are important to enable and improve concerted action without having a master plan. In the course of such developments, existing organisations may transform themselves. As noted already, research funding agencies may go further than their traditional role of funding research proposals, now adding reference to a Grand Challenge, and becoming brokers, playing a role in defining and/or managing concerted actions (Kuhlmann and Rip 2016).

One could think of Grand Challenge consortia, public–private set-ups, including charitable foundations, being responsible for concertation. A very visible example is the Bill and Melinda Gates Foundation, pro-active in public health and developing countries, and creating a separate consortium with a few governments (the traditional candidates like Canada, Sweden and Switzerland, but also Brazil and India) and a few big firms, to support and orchestrate working towards this societal challenge (Lancet 2009).

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The notion of 'concertation' has already been discussed in the second section of this chapter. It should be complemented by the notion of 'assemblage' of innovative sociotechnical configurations. Grand Challenges require new scientific and other knowledge and innovation, different from traditional priority lists of science policy. This includes novel ways of assembling and re-assembling heterogeneous bits of work (including traditional knowledge and innovation) into evolving sociotechnical configurations that address a Grand Challenge, including modifying it. One can make a comparison with the move, particularly visible in the automotive industry, of (motor car) companies becoming assemblers rather than builders, and redefining their overall product in terms of (auto)mobility.

A key lesson is that actors who could play a central role in concertation to address a Grand Challenge should be assemblers rather than builders. Such a role can be taken by charitable foundations which increasingly play active roles in public–private partnerships aiming at (transformative) innovation (Krull 2016). One could also think of funding agencies (research councils) expanding on their broker role. Here, we are moving away from a focus on government and its responsibilities to consider the possibility of challenges (Grand or otherwise) being taken up in the knowledge and innovation system more generally, rather than being a response to government push. This is important because most of knowledge production and innovation take place outside the sphere of direct influence of government agencies. New constellations of actors can emerge this way (cf. the move towards open innovation, e.g. Ghisetti et al. 2015).

The government role, apart from joining in the concertation, could be to offer legitimation, for example by creating spaces for such consortia (Rip and Joly 2012). Government could also ensure that there is regular reflection on the nature of the Grand Challenges and the role of various actors (and ensure a link with democratic decision making).

SCIENCE POLICY COPING WITH SYSTEM TRANSFORMATION AND UNCERTAINTY: MODES OF GOVERNANCE

In conclusion, in this chapter we have traced emerging modes of governance that have the potential to cope with the 'challenge of addressing Grand Challenges' and that could become characteristic of a next generation of science policy.

Science – understood as the institutions, actors and technologies of knowledge production and as a key resource for societal development and innovation – has always been triggered and shaped by state agents and

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related public policies. At the same time, the problem views of governmental and public policy actors have been influenced to a relevant degree by scientific understandings of nature, society, and related needs to act upon them (Jasanoff 1997, xiv–xv). In this co-evolution of 'science' and 'public policy', both poles are developing on a continuum of structured, rule-driven agency on the one hand and complexity-driven uncertainty on the other (science: canonisation of knowledge vs open-ended creativity; policy: modernist, purposive agency vs post-modern relativity).

A telling example of the co-evolutionary nature of the science and policy relation was the emergence and evolution of research councils as funding institutions. Research councils started out as channels for state patronage of science (a widespread phenomenon after World War II) and were captured by the scientists through peer review of proposals, panel participation, and board membership (Rip 1994). But then there was public and political pressure on the research councils, for example towards demonstrating the relevance of publicly funded research, and towards opening up to stakeholders – with scientists sometimes reluctantly, and sometimes eagerly, embracing the changes.

The uncertainty and open-endedness of scientific endeavour and policy-makers' need to establish legitimacy for public intervention are driving forces of this evolution, an evolution of opening and closing windows for new generations of science policy. This holds in particular if science and policy are becoming part of a transformation of wider system contexts (knowledge and innovation systems; sociotechnical systems). The perceptions of what is 'problematic' and which transformation is necessary will depend on the 'nature' of different challenges; they will be contested, will be negotiated and will evolve over time. Hence, Grand Challenges and related transformations will remain open-ended.

Many present-day challenges, grand or otherwise, are too complex to be addressed in versions of a 'command and control' mode. There will still be roles for central, authoritative actors, in particular governments, but their interventions will be rather attempts to modulate or nudge ongoing dynamics. Also, a substantial part of governance as it actually happens is de facto governance, that is, the guidance is effectively embedded in evolving social ordering drawing on sources of legitimacy (Rip 2010).

Foresight studies suggest (e.g. van Oost et al. 2016) that next generation science policies will not necessarily remain a responsibility mainly of governments but will become an integral part of the functioning of knowledge and innovation systems – which will be transformed themselves, including new sponsors and new performing actors. Future science policy designs can build on 'creative corporatism' (Ornston 2013), a concept in which governments (and/or related international alliances) will adopt the crucial

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role of facilitating broader, more diverse 'varieties of cooperation' in advanced capitalist economies. In this context we suggest a number of key governance approaches, supposed to facilitate creative knowledge production in the context of transformative change in constructive and productive ways: meta-governance and tentative governance; concertation and assemblage; capability and capacity building.

Meta-governance: Given the open-endedness of the ongoing transformations, with emerging new spaces for articulating and negotiating problem views of diverse actors and innovative ways of coping with problems, governmental actors would have to foster 'meta-governance' as 'organising the conditions for governance' (Jessop 2002, 242) by self-organisation, thus complementing the modes of market exchange and hierarchic command. Meta-governance will help to experiment with governance constellations that can be more or less productive in a particular context. An important example of such a meta-approach to governance is tentative governance. Situations where there is an open-ended mission, evolving over time, partly because of the work that is done to address the mission, are not limited to Grand Challenges. This is one of the reasons why the notion of 'tentative governance' has been introduced to capture 'provisional, flexible, revisable, dynamic and open approaches that include experimentation, learning, reflexivity, and reversibility' (Kuhlmann et al. forthcoming). Tentative governance is designed, practised, exercised or evolves as a particularly dynamic process to manage interdependencies and contingencies in a non-finalising way, rather prudent and preliminary than prescriptive and persistent. It creates spaces of openness, experimentation and learning instead of trying to limit options for actors, institutions and processes.

Concertation and assemblage: The particular meta-governance arrangement we focus on is the move towards concertation by bodies at arm's length from central policymakers. We consider concertation as a form of coordination by mutually taking actions of others into account and pro-actively adjusting, thus creating the basis for concerted action. Governments (and their alliances) can adopt the role of a coordinating change agent who is trustable, non-partisan and ready to invest. Concerted actions in open-ended transformative environments will require experimental and creative 'assemblages' of innovative sociotechnical configurations.

The success of such a move, for traditional institutions of science as well as semi-independent concertation bodies, will depend on the context. Societal agenda-building and credibility pressures are important for the articulation of, and action towards, Grand Challenges; the easy reference to 'green energy' can serve as an example: it is broader than demand orientation because there is not a concrete demand, but a diffuse concern

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and a willingness to refer to it when shaping actions and justifying them. Addressing Grand Challenges will then not just be taking up such open references and turning them into new priorities, or just arguments why a direction that is taken for other reasons can be legitimated. It is also about learning about their nature and ways to address them.

Capability and capacity building: Like current science and innovation policies, the next generation will also have to draw on strong material and intellectual infrastructures. While governments move from orchestration to concertation, they remain responsible for the public interest, keeping two major tasks: (1) there is a continued if not increasing need for targeted investment (cf. Mazzucato 2015) in knowledge bases and market creation (not least through demand-based policies); (2) transformation-related concertation requires learning, with new capacities and capabilities. The evolution of open-ended missions (as to their nature, co-evolving with implementation) needs to be evaluated, not least to create accountability in our democratic societies. Hence, concerting change agents need to build competence in 'navigation': drawing on diagnostic and prospective studies ('Strategic Intelligence'), consulting stakeholders, facilitating deliberation, moderating negotiations, enabling to package and perform. More specifically, such capability and capacities will have to be built for 'meso-level' actors: ministries, funding organisations, or boards of research organisations, of companies and of civil society organisations (Kuhlmann et al. 2015).

We started out stating that Grand Challenges are transformative, and we have discussed how to address such challenges. The further and deeper implication is that the ongoing transformations and the emerging modes of governance need continuous critical observation, analysis, evaluation and reflection. Such reflexivity is a key requirement and can become a productive source of learning for a next generation science and policy.

NOTES

* This chapter draws heavily on our paper 'Next generation innovation policy and Grand Challenges' for a Special Issue of *Science and Public Policy* (Kuhlmann and Rip 2018).

1. After the academic-disciplinary mode of knowledge production of Mode 1, there are now new sites of knowledge production ('discovery in the context of application'), transdisciplinarity and (hopefully) new ways of quality control. Together, these make up Mode 2. Scientific communities will lose their grip on knowledge production, but it is unclear what will take their place. This point is taken up further in the sequel to the 1994 book, Helga Nowotny et al. (2001), which discusses 'recontextualisation' of science, and in general pays more attention to interactions with society, and proposes an 'agora' to support democratising science. See also Rip (2000), Hessels and van Lente (2008), for critical evaluations.

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2. In Ziman (1994), his larger diagnosis is about 'collectivisation' of research combined with steady-state funding which create a new situation, leading to a change in the norms of doing science from CUDOS (the Mertonian norms: Communality, Universalism, Disinterestedness, Organised Scepticism) to PLACE (Proprietary, Local, Authoritarian, Commissioned, Expert work). He paints these changes as inevitable, but not necessarily good for science (or society). And he adds that the 'blizzard of buzzwords' of recent science policy and research management does not help either.
3. http://www.sussex.ac.uk/spru/newsandevents/2016/awards/consortium (accessed 12 September 2016).
4. http://www.undp.org/content/undp/en/home/sustainable-development-goals.html (accessed 9 September 2018).

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